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# PORTABLE PNEUMATIC OSCILLOGRAPH AND SMALL (PORTABLE) MECHANOCARDIOGRAPH

- USSR -

by S. T. Tsukkerman



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# PORTABLE PNEUMATIC OSCILLOGRAPH AND SMALL (PORTABLE) MECHANOCARDIOGRAPH

[This is a translation of an article by Professor S. T. Tsukkerman of the Leningrad Institute of Precision Mechanics and Optics, and published in Izvestiya Vysshikh Uchebnykh Zavedeniy, Priborostroyeniye, (News of Institutions of Higher Education, Instrument Building) No. 3, 1959.

## History of the Problem and Purpose of the Work

During the 1950 to 1951 period the author was in charge of the development of a design and the construction of an experimental model of a new medical device of the cardio-vascular system in humans and animals, called the "mechanocardiograph." This apparatus was being developed by the Leningrad Institute of Precision Mechanics and Optics according to the idea of Professor N. N. Savitskiy, being essentially a pneumatic oscillograph. During the course of this work we accumulated unique experience in the design, calculation, and investigation of an oscillograph with a pneumatic track.* The most important part of the work, which made it possible to construct a modern engineering model of a pneumatic oscillograph was the design of a new mirror micro-pressure gauge of an original construction and possessing sufficiently high technical properties as regards sensitivity, accuracy of performance, natural frequency, and stability of results.**

On the basis of accumulated experience the author made a proposition in 1952-1953 to develop several varieties of a pneumatic oscillograph for technical uses, and primarily apparatus for sample tests in hydrotechnical and aerodynamic laboratories.

As a result of work conducted by the Chair of "Special Optical Apparatus" of the Leningrad Institute of Prec. Mech. & Opt., there were designed and produced between 1953 and 1955 experimental models of stationary oscillographs: "Apparatus for

*Purposes, principle of operation and design of the "mechano cardiograph," see booklet "Description and Operation Instructions for the 'Mechanocardiograph' Apparatus," LITMO (Leningrad Institute of Precision Mechanics and Optics), 1956.
**See article by the author "New Mirror Micro-Pressure Gauge," Priborostroyeniye, No. 8, 1957.

Recording Low Pressures," (PMD and PMD-1)* and "Apparatus for Measuring Low Velocities of the Air (Pms and PMS-1)** and some others.

The above mentioned apparatus, manufactured in small lots, found practical application in hydrotechnical and aerodynamic laboratories.

As regards the "mechanocardiograph," this apparatus was widely distriubted and successfully used in a number of scientific and educational institutes and clinics as a stationary apparatus, manufactured by master mechanics of LITMO in a quantity in excess of 50. (At the present time it is made ready for assembly-line production to start in 1960 in factories of the Leningrad Sovnarkhoz).

In order to make the "mechanocardiograph" available for field use and for bedside use of critically ill persons, following the requests of a number of medical organizations, the Chair and Professor N. N. Savitskiy's Clinic designed in 1955-1956 the so-called "portable mechanocardiograph" (PMK) and produced it in an experimental series.***

Due to its relatively large dimensions and other shortcomings, this apparatus did not fully satisfy the requirements of medical institutions. Thus, the problem of producing a convenient, small size and reliable "mechanocardiograph" remained unsolved.

On the other hand, publication of experimental data accumulated by the Chair made it possible for us to pose the problem of the feasibility and advantages of using a pneumatic oscillograph in a number of technical measurements, for example: accelerations, small displacements, control of performance of various pneumatic machines and devices, etc.****

Requests made by a number of scientific research

*For details see: Collection of Annotations of Scientific Research Work conducted by LITMO, 1953 to 1956, LITMA 1956, and the author's booklet "Apparatus for Measuring Low Pressures" published by the Institute of Technical Information of the Acad. Sci. USSR, in No. P-56-423, 1956.

**For details see: the collection cited above and the author's article "New Apparatus for Measuring Velocities of Air and Gas Streams," in Izvestiya Vysshykh Uchebnykh Zavedeniy, Ministry of Higher Education, USSR, division "Priborostroyeniye," No. 3, 1958.

***For details see the above cited collection of annotations, LITMO, 1956.

****For details see the author's article "Pneumatic Oscillograph" in the collection "New Methods of Control and Defectoscopy," GOSTEKHIZDAT, UkSSR, 1958.

institutes, universities and OKB (Experimental Design Bureaus) to us, confirmed the need of a portable pneumatic oscillograph for technical applications.

Pursuant to what has been stated above, in 1956 the Chair initiated the planning and development of an experimental model of a uniform portable pneumatic oscillograph which could be released as a technical oscillograph as well as a "mechano-cardiograph" by merely supplementing it with various accessories and by exchanging a small number of parts.

After conducting a series of experiments and making additions, this experimental model was successfully completed early in 1957.

During the course of 1957 we completed designs and blueprints of both modifications of the oscillograph and in 1958 we made experimental models of a technical pneumatic oscillograph and of a portable "mechanocardiograph."

The main purpose of this article is to present technical data and possible uses of the above named apparatus.

## Portable Pneumatic Oscillograph

A portable pneumatic oscillograph is meant to be used in these instances when there is a need to record the fluctuations of pressure or of the velocity of the air or gases, for example: in investigating the performance of pneumatic machines, motors, brakes, fluctuations of pressure and velocity of turbine pipes, pressure control devices, etc.

The performance diagram of a pneumatic oscillograph, in which the pressure to be measured is directly conducted to the mirror pressure gauge and which makes the recording, provides for the greatest simplicity, reliability and precision in comparison with apparatus which transforms pressure into an electrical signal.

By means of selecting pressure gauges of different sensitivity and of intermediate pick-offs (pressure transformers), the pneumatic oscillograph is capable of recording pressures of practically any range, starting with fractions and units of mm of a water column, up to hundreds of $kg/cm^2$. The only limitation of applying the pneumatic oscillograph is the high frequency of oscillations, since at frequencies above 30 — 40 cps amplitudinal errors begin to appear due to the low natural frequencies of the pneumatic track and of the mirror micro-pressure gauges.*

The described model of a pneumatic oscillograph is

*More details on the performance diagram of thetheoretical premises and characteristics of a pneumatic oscillograph will be found in an article by the author "Pneumatic Oscillograph" in the collection "New Methods of Control and Defectoscopy," Gostekhizdat, UkSSR, 1957.

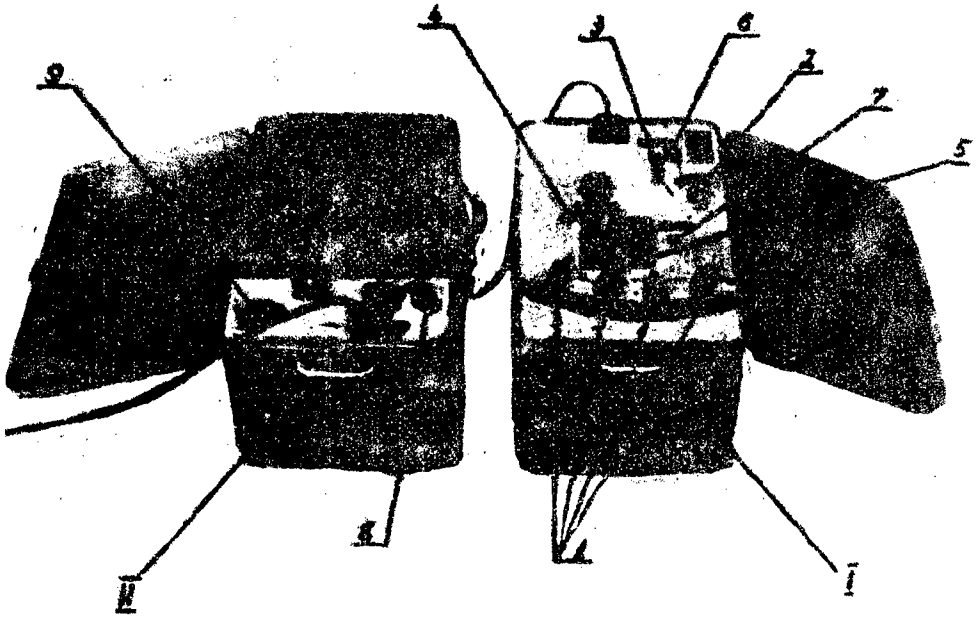


Fig. 1

designed for simultaneous recording of pressure fluctuations from four pick-offs, within the following range of change:

0 to 15 mm of water column
0 to 50 mm of water column
0 to 150 mm of water column
0 to 1000 mm of water column
0 + 3 kg/cm$^2$.

In order to reduce the weight and clearances, and the dependence on sources of electric power supply, recording in the apparatus is made on a regular 35mm photographic film which is moved by means of a hand cranked mechanism. Electricity for the light bulb of about 3 v. can come either from a pocket battery or from a transformer plugged into a home circuit of 127/220 v.

An essential and original feature of the apparatus is the optical printing on the film simultaneously with recording of the numerical scales of amplitude (pressure) and time (Fig. 3) which makes it much easier to decipher the results obtained. The high uniformity of the film motion, upwards of one percent, makes it unnecessary to install a special time marking device in the apparatus.

The whole set of the pneumatic oscillograph consists of two identical cases (the apparatus itself - I, and the case with accessories - II) measuring 320 X 220 X 220 mm (Fig. 1), and

weighing about 6 kg and 3 kg, respectively.

The controls can be seen on the panel board of the apparatus: handles of the pressure gauges 1, handle of film speed control 2, starting handle 3, button for printing record numbers 4, screen for visual control of recording 5, gauge of film supply 6, and gauge of "power supply" 7.

The panel board of the case with accessories shows switch handles 8 of the "battery-circuit," and of the filament resistor of the bulb 9. This case contains the battery and transformer, as well as spare parts and accessories. Figure 2 shows the basic accessories of the apparatus: feeding 1 and receiving cassette 2, mirror micro-pressure gauge 3 together with intermediate pick-off 4 and connection pipe, and vertical pressure gauge 5 (for pressure up to 3 kg-cm$^2$).

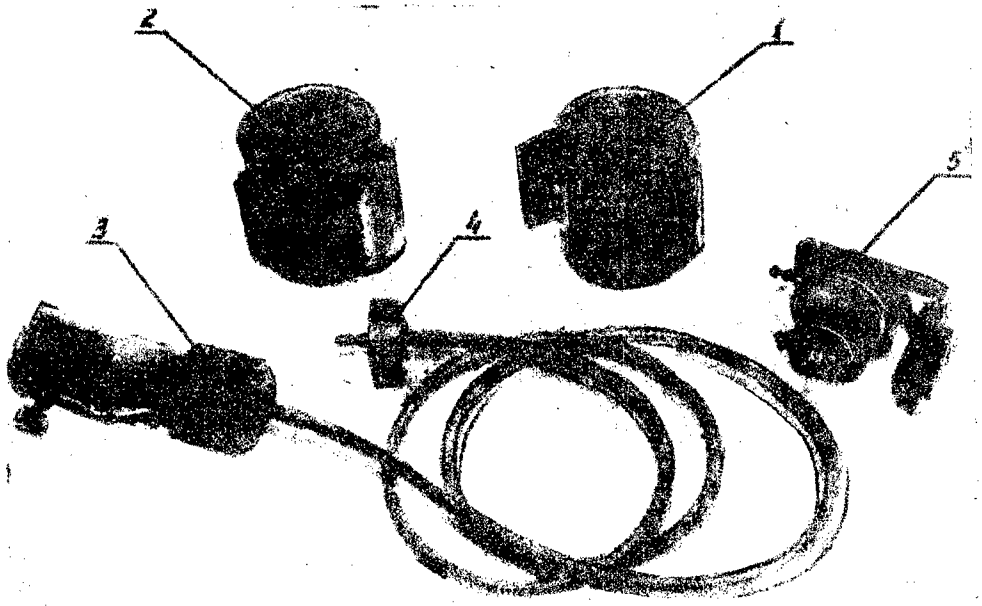


Fig. 2

The apparatus has 6 speeds of film movement, i.e., 48, 24, 12, 8, 6 and 2 mm/sec.

At speeds of 48, 24 and 8 mm/sec the time of running without a booster is 3 minutes, and uniformity of movement above one percent.

At speeds of 12, 6 and 2 mm/sec the time of running without a booster is 12 minutes, and uniformity of movement above four percent. In both cases can be seen on gauge 7 (Fig. 1).

The feeding cassette will hold up to 5 m of film and the receiving cassette up to 3 m. In order to show parts of exposure part of the film can be cut off with a special cutter.

During recording on film by optical means the following is printed: the figure indicating film speed 1, and figure 2 showing the number of recording. Figure 3a shows in magnification a sample recording made by the apparatus at a speed of 8 mm/sec. Longitudinal lines 3 give the scale grid of pressure, and the latitudinal 4, 5 and 6 -- the time.

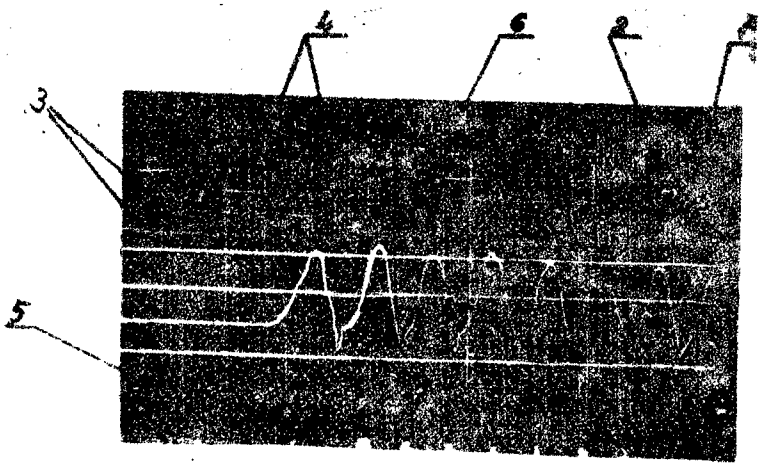


Fig. 3a

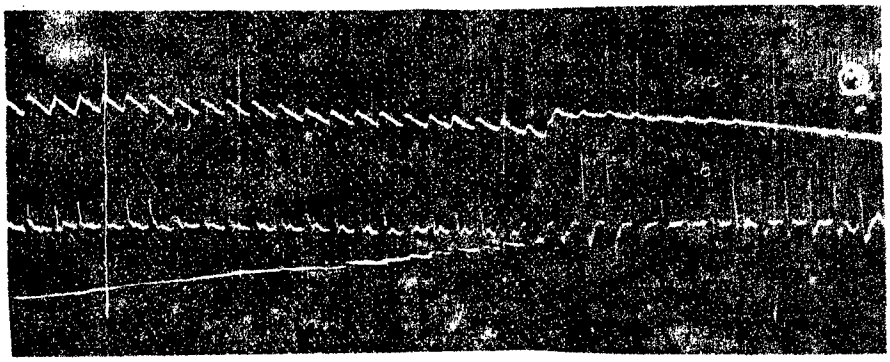

Fig. 3b

For the sample recording given in Fig. 3a the distances between lines 4 correspond to 1.5 sec, between lines 5 --0.15 sec., and between lines 6-- 0.06 sec.

The thickness of the recording line obtained from the pressure gauge is 0.1 mm and the thickness of the lines of the scale is 0.03 mm. The performance accuracy of the apparatus on amplitude is 2 percent on condition of prior adjustment of the pneumatic track.

The natural frequency of the mirror micro-pressure gauge is 120 cps, and of the pressure gauge (up to 3 $kg/cm^2$)

above 300 cps.

The apparatus records pressure oscillations without noticeable amplitude errors at a frequency to 30÷40 cps depending on the length of the connecting pipe (with errors it is possible to record up to 100 cps and higher)*

Tests of practical use of the apparatus gave positive results.

## Portable "Mechanocardiograph"

As noted before a portable "mechanocardiograph" is used for the same analyses as a larger or stationary apparatus, but in the field or at the bedside of a patient as well as at stadiums, on ships, aircrafts, etc.

The design of this apparatus has been made to conform with the portable pneumatic oscillograph as to dimensions and a majority of parts.

A comparison of Fig. 4 showing the general view of the portable "mechanocardiograph" with Fig. 1 proves what has been said above.

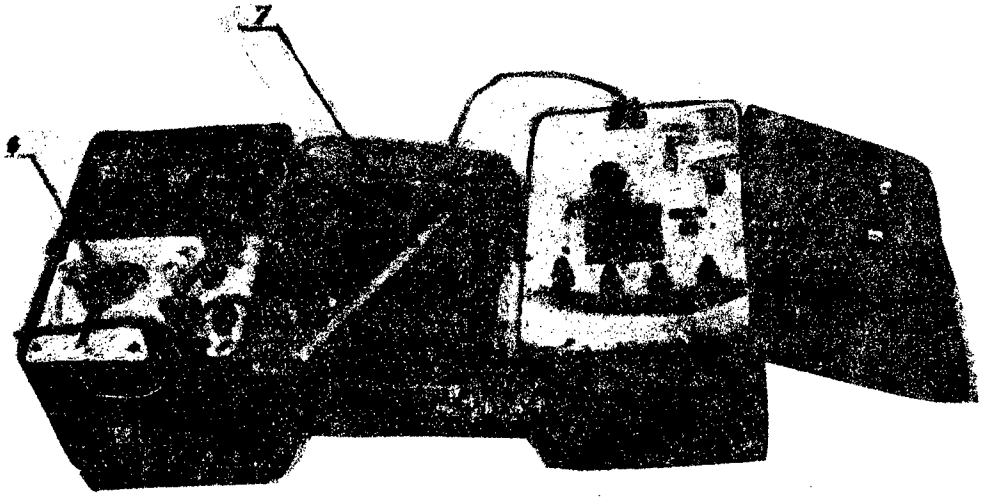

Fig. 4

The apparatus makes it possible to make a simultaneous recording from four pick-offs: two pulse, arterial and differential pressure.

The differences between the portable "mechanocardiograph" and the portable oscillograph described above are as follows:

1. The apparatus is equipped with a different set of

*For details of the design and technical data see "Description of Pneumatic Oscillograph 'PTO'," LITMO, 1958.

pressure gauges, pick-offs and accessories. The set comprises three pulse differential pressure gauges 1 (Fig. 5), a structurally and technically analogous mirror micro-pressure gauges, the "arterial pressure gauge" 2, i.e., a mirror pressure gauge with a range of measuring a 300 mm mercury column. The pick-offs are: suction cups 3, cuffs 4 and pulse feelers 5.

In addition the set includes a tank with compressed air 6, and pump 7, which are carried in the accessory case.

2. The apparatus runs at different speeds of film movement, viz., 24, 12, 6, 4, 3 and 1 mm/sec.

3. The scale diagram recorded on the film (as well as the scale on the visual screen) is divided into millimeters of a mercury column (from 40 to 280 mm) for direct determination of blood pressure.

A sample recording made with a small mechanocardiograph is shown in Fig. 3b.

The mechanical and optical parts of the portable mechanocardiograph are analogous in design and construction to those of the pneumatic oscillograph.

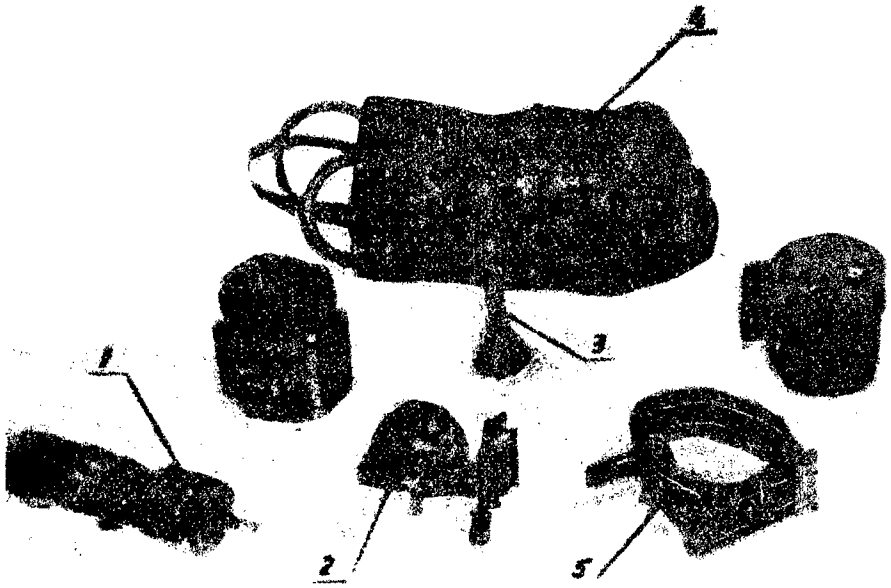


Fig. 5

It should be noted that the portable "mechanocardiograph" has a greatly improved and simplified construction of a compressed air tank and pulse pick-off in comparison with the stationary model, which considerably facilitates and speeds up work with the apparatus.*

*For more details of design and technical data on the apparatus see "Description of Small Mechanocardiograph," LITMO, 1958.

Tests made of a model of a portable "mechanocardiograph" under clinical conditions gave good results.

## Conclusion

The Chair of "Special Optical Apparatus" of LITMO produced during the last years a number of new original models of a pneumatic oscillograph, made a number of experimental tests and accumulated considerable design experience.

Successful practical application of the apparatus and numerous reports made to us by very different organizations confirm the utility and practicality of wide practical uses of the apparatus developed by us, and of conducting investigations and design work for the further improvement and increase of the scope of their use.

Recommended by the
Chair of "Special
Optical Apparatus"

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14 April 1959

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